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ABSTRACT

This paper presents the findings from an evaluation of SUCCEED (Southwestern University and College Coalition for Engineering Education), a National Science Foundation (NSF) coalition. The presentation is made in several stages: (1) a review of the background and goals of the NSF coalitions, SUCCEED in particular; (2) a discussion of the methods used in the evaluation and a summary of the major findings to date; and (3) discussion of the implications of SUCCEED's experiences for other programs aimed at reforming engineering education. The vision of the coalitions is one in which all engineering graduates will possess highly developed technical skills, the attitudes and awareness needed to prosper in the workplace, and motivation to enhance the nation's competitive position in world markets. Evaluation results indicate that the coalitions have contributed to increased access to technology, early exposure to engineering, and outreach towards minority groups. (DDR)

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Curriculum Reform and the NSF Engineering Education Coalitions: A Case Study

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Curriculum Reform and the NSF Engineering Education Coalitions: A Case Study

The National Science Foundation (NSF) Engineering Education Coalitions represent one of the most extensive efforts ever undertaken to reform undergraduate education. Involving dozens of institutions and upwards of $500 million over a ten-year period, the NSF coalitions are founded on a vision in which all engineering graduates will possess not only highly developed technical skills, but also the attitudes and awareness needed to prosper in the contemporary workplace and to enhance the nation's competitive position in world markets.

The purpose of this paper is to present findings from an evaluation of one of the NSF coalitions--SUCCEED (the Southeastern University and College Coalition for Engineering Education). The presentation will proceed in several stages. First, it will briefly review the background and goals of the NSF coalitions, and of SUCCEED in particular. Then, it will discuss the methods of the evaluation and summarize the major findings to date. Finally, this paper will consider the implications of SUCCEED's experiences for other programs that aim at the reform of engineering education.

Background

The demand for educational reform in engineering can be traced to the historic split between what Geiger (1994, p. 283) has called the profession's "shop" and "school" cultures. Originally focused on process and product engineering and other practical applications, undergraduate education gradually shifted to a more purely scientific orientation. The engineering curriculum became frontloaded with mathematics, physics, and chemistry requirements, while engineering courses were delayed until the final two years of study. One result was a high attrition rate, as freshman and sophomores expressed their frustration at the abstract conception of engineering embodied in the undergraduate curriculum. A related issue was that recent graduates were perceived by many employers as lacking the social, political, and communications skills needed to advance in modern corporate environments. (See, for example, Augustine, 1996.) Accordingly, the vision of engineering education that NSF hoped to achieve through its sponsorship of the coalitions was one in which all graduates would have

> disciplinary depth plus integrative abilities and experience in designing and manufacturing 'products.' They will have to know how to synthesize and integrate knowledge, handle ambiguity, and work in teams to develop the best solutions. They will also need to understand how to factor societal, environmental, and market considerations into their solutions. (Preston, 1993, p. 27).

The SUCCEED Coalition

Established in 1992, SUCCEED is a coalition of eight schools of engineering: Clemson, Florida State/Florida A. & M., Georgia Tech, North Carolina A. & T., North Carolina State, the University of Florida, the University of North Carolina--Charlotte, and

Virginia Tech. The coalition's primary goal is to implement, evaluate, and disseminate Curriculum 21, which is not a prescribed sequence of courses but a statement of principles for undergraduate education. Among these principles are the integration of engineering with other subjects, including mathematics, the natural and social sciences, and the humanities; the enhancement of performance skills, such as problem solving, teamwork, and communications; the infusion of engineering practice into coursework; the provision of multidisciplinary team experiences, in both campus and workplace settings; and the incorporation of information and communications technology (SUCCEED, 1995, pp. 3-4). Along with curriculum reform, SUCCEED is also committed to three other goals: Adopting Total Quality Management principles on a coalition-wide basis; increasing retention rates, especially among women and students from underrepresented minority groups; and promoting outreach to secondary schools and community colleges.

In order to achieve these goals, SUCCEED annually funds projects developed by faculty and staff at the member campuses. Mindful of the need for broad-based evaluation and dissemination, the coalition encourages multisite, multidisciplinary projects and those that make use of the Internet and other advanced technologies. To encourage local involvement in project development, the funds provided by SUCCEED must be matched dollar-for-dollar by the host institution or other sources.

Evaluation Methods

The information and conclusions in this report are taken from an ongoing evaluation of SUCCEED's first through fifth years. The overall aim of the evaluation is to determine the progress that the coalition has made toward the achievement of its major goals. The two primary components of the evaluation are a qualitative study of program implementation at each of the eight coalition sites, and a quantitative study of student progress. With respect to the qualitative study, data are drawn from interviews with nearly 200 individual participants, including faculty members, students, administrators, graduates, and employers, and from from documents (mainly annual reports, proposals, and coursewares). The principal data source for the quantitative analysis is the longitudinal data base (LDB), which was designed by SUCCEED expressly for the purpose of tracking students' progress toward program completion at each member institution.

These two components of the evaluation are intended to complement one another. When completed, the LDB will provide a comprehensive profile of student enrollment and attainment for the entire coalition. On this basis, it would be possible to infer whether the programmatic changes introduced by SUCCEED are associated with reductions in attrition among engineering majors in general and among women and underrepresented minorities in particular. Yet such inferences would be of limited value and of doubtful validity without the participants' perspectives that are included in the qualitative study. Taken together, then, the qualitative and quantitative dimensions of the evaluation will provide a relatively complete picture of the educational reform efforts of the SUCCEED coalition.

Findings

The overall finding of the evaluation is that SUCCEED has thus far made substantial but incomplete progress toward the achievement of its goals. Although SUCCEED has attracted only about one-fifth of the coalition's combined engineering faculties to its cause, it has registered some substantial accomplishments in the area of curriculum reform, including the following:

- Increased access to technology. In the words of one informant, "SUCCEED and the other coalitions have started off a whole new area for using multimedia in education. They've seeded the area and [the growth that has occurred] couldn't have happened without them." Key contributors include not only those projects whose mission is multimedia development and electronic connectivity, but also those courses that routinely make coursewares available on CD-ROMs or on the WorldWideWeb.

- Early exposure to engineering. Freshman engineering labs, based on Curriculum 21 and quality principles, have already been institutionalized at several coalition sites. More generally, interviews with students suggest that by providing access to engineering content early in their undergraduate careers, SUCCEED's Stage I courses may help to reinforce the initial choice of an engineering major.

- Horizontal integration. Cross-disciplinary courses, involving the integration of engineering with humanities, mathematics, and the natural and social sciences, exist at nearly every SUCCEED site.

- Vertical integration. Contact, collaboration, and mentoring between newcomers and advanced students were key features of some SUCCEED courses.

- Teamwork, "real world" problem-solving, and diffusion of responsibility. Approaches that provided students with opportunities for leadership and responsibility were well-received, as were those courses that were focused on corporate partnerships and other practical applications.

- Minority outreach. Summer programs, based on a model developed at Georgia Tech, have been implemented at all sites. These programs provide entering freshmen with an orientation to campus life, a head start on their academic studies, and access to a network of peers and mentors.

Efforts to link these qualitative findings to increased retention and other student outcomes have been slowed by the complexity of the data management tasks surrounding the creation of the LDB. Equally important is that those students most likely to have been affected by SUCCEED (i. e., those who began their freshman year in 1992-93 or thereafter) are presently in the fourth year of studies and thus are not quite at the point of

program completion. Accordingly, the fifth and sixth-year data on program completion, which are often considered the most meaningful evidence of student retention, won't be available for another year or two. Nevertheless, there are provisional indications that some SUCCEED-sponsored activities may be having the desired effect. For instance, the introduction of intensive preseason programs, which are offered to entering freshmen from minority backgrounds, may help to explain the higher rates of retention observed among African-American engineering sophomores across the coalition. On the other hand, there is little indication of similar effects among community college transfer students (for whom a summer orientation program exists at one site) or among female students and other groups expected to benefit from SUCCEED's activities.

Implications

Whether or not the generally positive findings reviewed above will be forerunners of a broader pattern of success for the NSF coalitions is uncertain. One fundamental question has to do with the prospects for institutionalizing change within the engineering curriculum. A pattern that has been noted throughout American higher education in recent decades is that enthusiasm for change lasts only as long as the external funding. Once the foundation or government awards end, there has been a tendency for curricula and teaching methods to revert to the *status quo ante* (Fincher, 1986).

In the case of SUCCEED, the uncertainty is highlighted by a comment made by many principal investigators (and even by some of the administrators with whom we spoke) that instructional improvement was a lower priority for their institutions than was demonstrated success in research. A similar finding has been reported for one of the other NSF coalitions (Fairweather, 1996). Although this issue may be especially significant in resource-rich fields like engineering, it appears to be true to some extent in all disciplines and in many different types of institutions. The reason has little to do with an innate preference for research or with contempt for teaching, as some critics of higher education claim. Rather, the explanation lies in the academic reward structure and ultimately in the economics of contemporary higher education. In the prevailing view, research generates more external resources (money and prestige) than does teaching and is thus rewarded accordingly (Clark, 1983).

Even though it is a prime sponsor of engineering research, NSF is, through the coalitions, seeking to establish an alternative reward structure as a means of achieving its long-term goal of enhancing the quality and competitiveness of engineering education. Hence, one of the key questions will be how top-level schools of engineering (and those that aspire to this status) will deal with faculty members who place greater-than-usual emphasis on educational reform. There is some evidence from the SUCCEED interviews that such efforts will be rewarded, but only under certain conditions--namely, that these efforts are conspicuously successful, well documented and disseminated beyond the home campus, and supported by one or more key decision-makers within the institution.

Another basis for optimism that emerges from the evaluation is that SUCCEED has functioned as a true coalition of institutions, in that it has established the means by which ideas and materials that are successfully tested at one site can be rapidly disseminated to other member institutions, and from there to the wider public. The emphasis on diffusion

means that the fate of an innovation does not depend on the sustained enthusiasm of faculty or administrators at any single site. This point is crucial to understanding one of the underlying features not only of SUCCEED but of the NSF coalitions in general--namely, the extent to which they rely on the dynamics of the marketplace to offset the pedagogical conservatism of higher education. To the degree that proposals are forced to compete with each other for initial and continued funding, and especially insofar as effective local products and ideas eventually enter into wider circulation, the expectation is that the quality and usefulness of an innovation will generally prevail over institutional inertia.

Future evaluations of the NSF coalitions should place prime emphasis on the market functions of these organizations. By capitalizing on the interinstitutional element of the coalitions, it should be possible to track an idea as it moves from one campus to another, and then to a web site, to a commercial publisher, and so forth. SUCCEED's proposal for a second five-year funding cycle includes an evaluation component intended to do precisely that. Organized in part around the theme of diffusion of innovation (Rogers, 1994; Tornatzky & Klein, 1982), this approach to evaluation would reveal not only whether a program attained its objectives, but, more importantly, how it did so on a campus-by-campus basis. Providing reliable access to information of this type would be a significant step forward both for program evaluation and for engineering education.

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